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RESULTS OF CERTAIN ELECTRO-PHYSIOLOGICAL INVESTIGATIONS ON THE "VOSKHOD" SPACECRAFT

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RESULTS OF CERTAIN ELECTRO-PHYSIOLOGICAL INVESTIGATIONS ON THE "VOSKHOD" SPACECRAFT

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ABSTRACT

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The crew of the "Voskhod" spacecraft included a doctor who performed operative medical control and studied the condition of the crew members. The apparatus used for this purpose is described. Author

The flights of the Soviet and American cosmonauts made it possible /1* to study functional changes in several systems of the human organism under the influence of complex factors encountered in cosmic flight, and particularly under the influence of prolonged weightlessness (N. M. Sisakyan, O. G. Gazenko, A. M. Genin, 1961; V. V. Parin and O. G. Gazenko, 1962; N. M. Sisakyan and V. I. Yazdovskiy, 1964, V. Frank, 1963; P. Webb, 1964). However, such problems as work capacity, fatiguability, degree of movement coordination and retention of a motor stereotype developed under terrestrial conditions have not been sufficiently clarified (Ye. M. Yuganov, et al, 1961; I. I. Kas'yan, et al, 1964; A. V. Yeremin, et al, 1965). In view of the complexity of these problems, it would be most expedient to include a doctor-physiologist having the appropriate equipment among the crew, in order to study the cosmonaut's condition during the flight. These ideas were incorporated during the flight of the

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* Note: Numbers in the margin indicate pagination in the original foreign text.

spacecraft "Voskhod".

Three men were included in the crew: the spacecraft commander pilot-cosmonaut V. M. Komarov, scientific assistant K. P. Feoktistov, and doctor-cosmonaut B. B. Yegorov.

During the flight the operative medical control was performed by two indices: the pulse rate and the respiration rate. These indices were continuously sent to the earth from each cosmonaut by means of short-wave radio communication using the apparatus "Signal" (Figure 1).

Periodically the data from the operative medical control were sup- /2 plemented by more detailed information obtained by the stations on earth using radiotelemetric channels (electrocardiogram, seismocardiogram, changes in the perimeter of the thorax). Along with this, the doctor-cosmonaut directly studied the crew members. He determined the pulse, rate and depth of respiration, magnitude of maximum and minimum arterial pressure, ventilation of the lungs, and he took samples of the inhaled and exhaled air. He took blood smears and performed functional tests, such as a study of the fusion ability of the eyes, sensitivity of the vestibular apparatus to a measured discharge by a galvanic current, and several other tests (about 15 in all). The doctor wrote down the results of these studies in tables which had been compiled previously and appeared in the on-board journal. If necessary, these data could be transmitted to earth by means of a specially-assigned channel.

A programmed inspection of each crew member, using the apparatus "polinom", occupied a special position in the work performed by the doctor. These studies were coordinated with the periods of the radio telemetric communication with stations on earth, where they were recorded on an individual

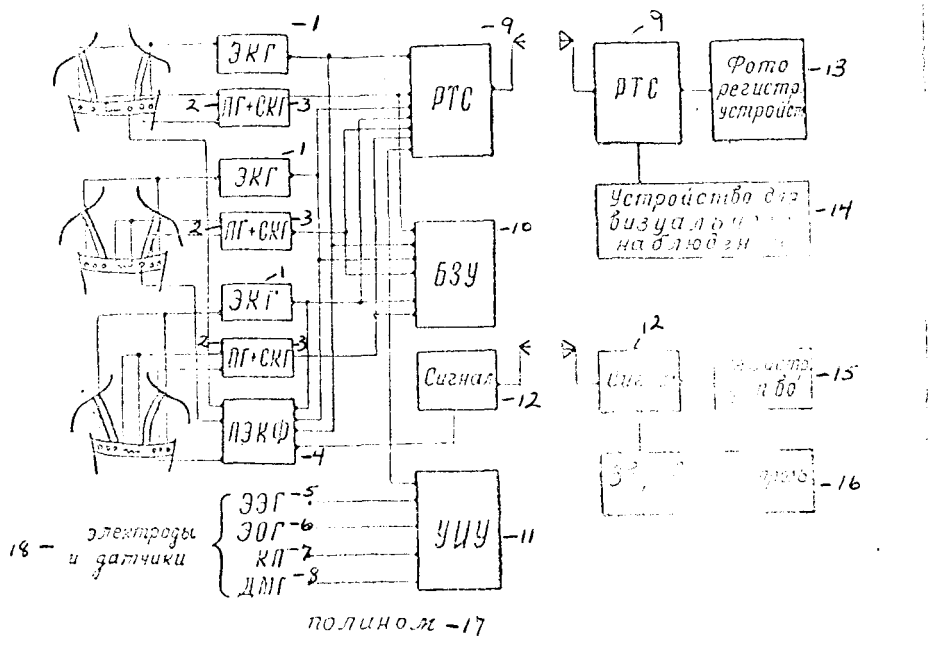

Figure 1

Block Diagram Showing the Recording of Physiological Parameters in the Crew of the "Voskhod" Spacecraft During the Space Flight:

1 - Electrocardiogram; 2 - Pneumogram; 3 - Seismogram; 4 - Pulmo-electrocardiograph (Signals of Pulse Rate); 5 - Electroencephalogram; 6 - Electrooculogram; 7 - Writing Coordination; 8 - Dynamogram; 9 - Radio Telemetric System; 10 - On-Board Memory Device; 11 - Amplifying-Indicating Device; 12 - Signal; 13 - Photo Recording Device; 14 - Device for Visual Observation; 15 - Recording Device; 16 - Sound Control; 17 - Polinom; 18 - Electrodes and Recorders.

photo block. Due to the great significance of these studies, we shall /4 deal with them in detail.

The apparatus "Polinom" consists of an instrument block and a recording system (Figure 2). The main instrument block is an amplifying device consisting of two-cascade preamplifier and a five-cascade amplifier. The distinguishing feature of the amplifying device arrangement is operation in an amplifying regime using variable voltage with a galvanic connection between the cascades. This apparatus makes it possible to record the following physiological indices consecutively on one radio telemetric

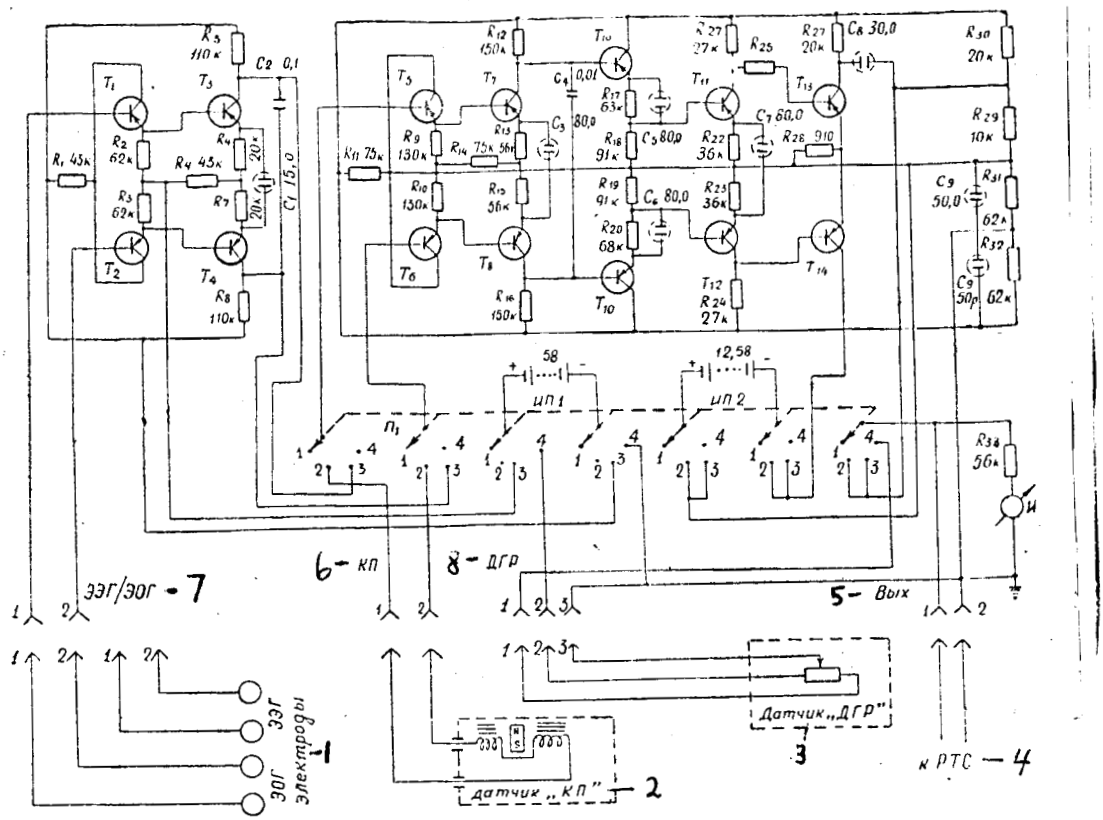

Figure 2

Diagram of Instrument Block on the "Polinom" Apparatus /3

1 - Electrodes; 2 - Writing Coordination Recorder; 3 - Figure Drawing Recorder; 4 - To Radio Telemetric System; 5 - Input; 6 - Writing Coordination; 7 - Electroencephalogram-Electrooculogram; 8 - Figure Drawing Motion

channel: the electroencephalogram (EEG), the electrooculogram (EOG), the dynamogram (DNG), and results derived from tests on movement coordination when writing or drawing specific geometric figures (KP).

Each of the crew members controlled the apparatus by using a switch which turned on the power and commutated the input and output circuits of the device.

The operation of the apparatus was controlled by an indicator located on the forward panel of the instrument block.

An elastic cap with EEG electrodes (forehead-occiput lead) and EOG electrodes (canthus lead), a potentiometric recorder for recording dynamograms (Figure 3), and an induction-type recorder for studying the movement coordination when writing (Figure 4) were included in the apparatus recording group. The recording system makes it possible for three crew members to operate these units by turns.

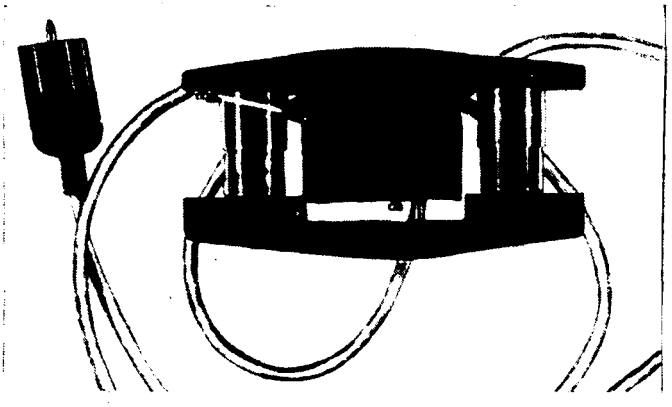

Figure 3
Potentiometric Recorder for Recording Dynamograms

A special program was developed to effectively utilize the time used /5 for studying the cosmonauts. At the beginning of this program, each crew member gave his own signal: commander of the apacecraft - one press on the dynamograph; the scientific assistant - two; the doctor - three.

After the signal was given, for forty seconds a test was made twice on the closing and opening of the eyes, with simultaneous recording on the EEG.

A test determining the accuracy with which four double spirals, sixes, and drawings were made was conducted on a special recorder for writing, which was initiated with open eyes and then with closed eyes.

A brush dynamograph was compressed rhythmically for several minutes, with the same force and for the same period of time.

The eyes were moved to the left and to the right in turn at the same angle from the center of vision. Then the head made ten rotating motions from left to right, and it was repeated to test the coordination of this motion with the eyes.

Each cosmonaut signalled with the same signal which he employed at the beginning of the program to indicate that the test was completed.

The volume of physiological information obtained during the flight from a programmed study of the cosmonaut is shown in Table 1.

As can be seen from Table 1, the program of functional tests was completely recorded for B. B. Yegorov, and it was partially recorded for K. P. Feoktistov and V. M. Komarov.

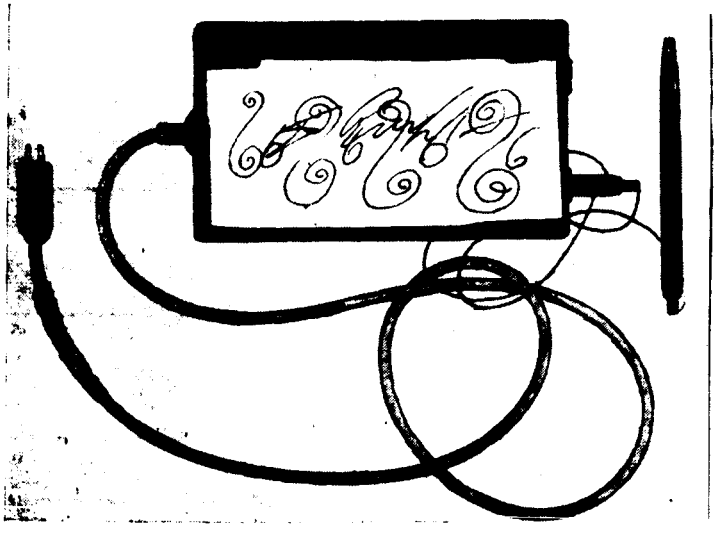

Figure 4

Induction-Type Recorder for Studying Movement Coordination During Writing. The test performed by B. B. Yegorov during the flight can be seen on the recorder screen.

TABLE 1

PHYSIOLOGICAL INFORMATION OBTAINED DURING THE FLIGHT USING THE "POLINOM" APPARATUS

Cosmonauts	Duration of Information Reception	Physiological Information Used			
		EEG	KP	DMG	EOG
B.B. Yegorov	4 min. 16 sec.	+	+	+	+
K.P. Feoktistiov	2 min. 02 sec.	-	-	+	+
V.M. Komarov	3 min. 45 sec.	+	-	+	+

Note: Information Reception Designated By +: Absence of Information Designated By -.

Figures 5 and 6 present samples of dynamogram recordings and tests on the movement coordination during writing on earth and during space flight. The recordings of the functional tests on earth were obtained at the end of a two-month training period for the cosmonauts*.

When the electroencephalograms of B. B. Yegorov and V. M Komarov are /7 analyzed, attention is drawn to the increase during the flight of the α-rhythm index, the increase in the α-rhythm amplitude with closed eyes, and a decrease in the latent activation period of the α-rhythm when the eyes are closed. These EEG changes point to an intensification of retardation processes in the cerebral cortex. It is interesting to note that the changes in the α-rhythm for V. M. Komarov were expressed somewhat more sharply, which is apparently due to the EEG recording at the end of the flight.

In an analysis of the writing tests of B. B. Yegorov, it is found that

* Doctors-physiologists A. Ye. Baykov and N. I. Budyak participated in obtaining and interpreting background data obtained from a programmed study of the cosmonauts.

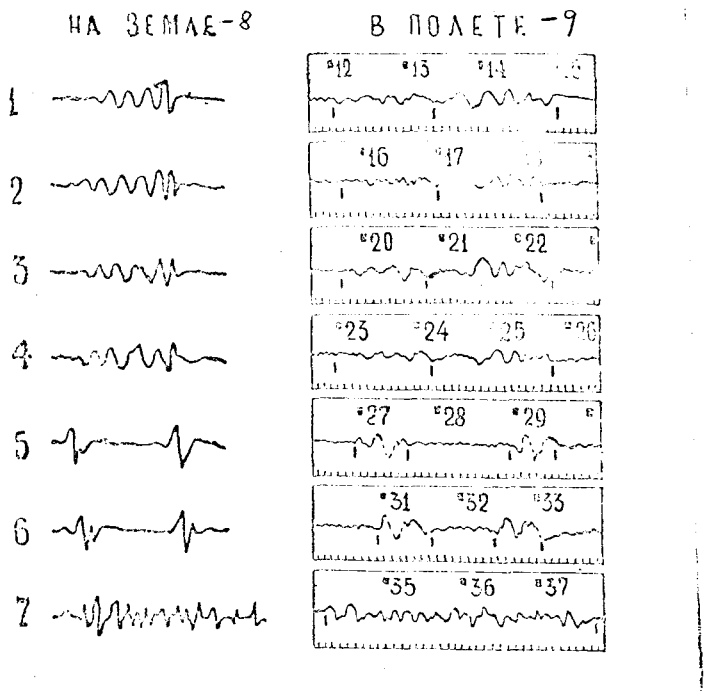

Figure 5

Samples Derived From Functional Tests by Cosmonaut B. B. Yegorov on the Movement Coordination When Writing With Closed Eyes, Under Conditions on Earth and During Space Flight:

1-4 - Double Spirals; 5-6 - Sixes; 7 - Drawing

8 - On Earth; 9 - In Flight.

during the flight the time required to perform double spirals with open eyes increases on the average by 51%, and with closed eyes - by 17%. A disturbance of the stereotype for the rate of motion when drawing individual elements of the spiral is also determined. Attention should be called to the fact that the motion stereotype is disturbed to a greater extent with open eyes than it is with closed eyes. Thus, it the amount of errors with open eyes, with respect to conditions on earth, amounts to 7:1 during the flight, then with closed eyes this relationship is 5:3. The motor skill in drawing sixes and figures changed during the flight

much less than it did for drawing double spirals. The time required for drawing sixes, both with open and with closed eyes, increased by 11-12% during the flight. The time required to draw figures with open eyes increased by 9% during the flight.

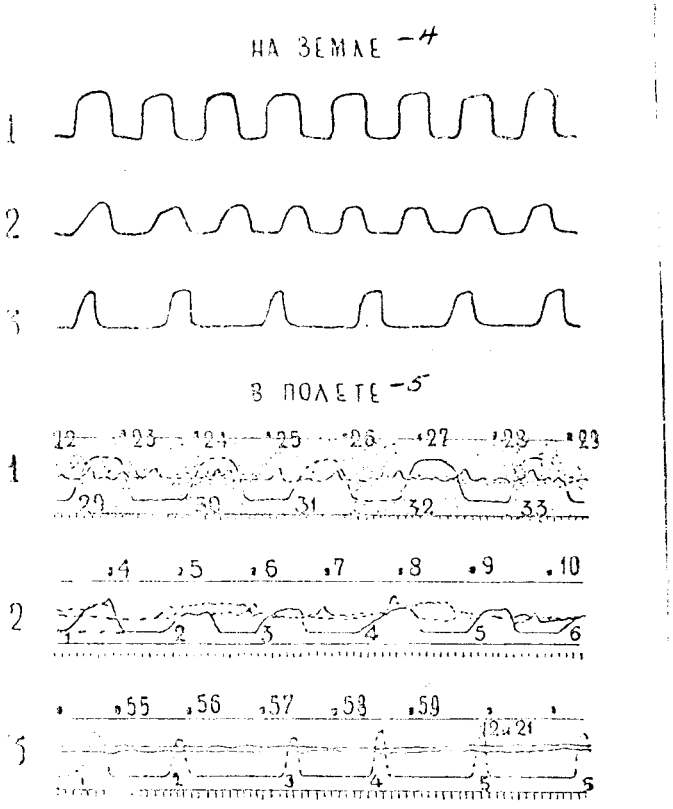

Figure 6

Sample Recordings of the Dynamogram for Cosmonauts V. M. Komarov (1), K. P. Feoktistiov (2), and B. B. Yegorov (3) Under Conditions on Earth and During Flight

4 - On Earth; 5 - During Flight.

When the DMG were analyzed, it was found that during the flight /8 B. B. Yegorov operated the dynamograph with a faster rhythm, with greater jerkiness in the pressing amplitude and rhythm, with a considerably shorter pressing duration, and with a rapidly increasing decrease in force. These

DMG changes point to a disturbance of the coordination-motor skills developed under conditions on earth and to a more rapid fatiguability.

K. P. Feoktistiov operated the dynamograph during the flight with a more widely-spaced rhythm as compared to conditions on earth, with greater unsteadiness in the pressing duration and the intervals between presses, but he retained approximately the same physical force applied to each press. The DMG changes point to the absence of physical fatiguability, and a disturbance of the coordination-motor skill developed under conditions on earth.

For V. M. Komarov, a curtailment was observed in the pressing rhythm, an increase in the duration of the presses, an increase in the unsteadiness of the rhythm and in the duration of the presses, as well as an increasing reduction in their amplitude during the flight, as compared with conditions on earth. These DMG changes point to a disturbance of the coordination-motor skill and to more rapid fatiguability.

An analysis of the EOG recordings shows that in all the cosmonauts' random motions with the eyes during the flight were fairly symmetrical - i.e., no disturbances were observed in the tonus of the oculomotor muscles. After stimulation of the vestibular apparatus by means of 10 rotating motions of the head, a small asymmetry was noted in the oculomotor reactions of B. B. Yegorov. Thus, if the amplitude difference in eye motions to the left and to the right comprised 0.05 on the average under conditions on earth,for this cosmonaut, then during the flight it was 0.17. After stimulation of the vestibular apparatus of K. P. Feoktistiov, the symmetrical eye motion barely changed. This test was not recorded on the flight for

V. M. Komarov.

The above changes in the physiological indices for all three cosmonauts are not pathological, but are related to the influence of complex factors during space flight. Part of the changes - for the EEG and DMG indices - express a poorly-defined fatiguability of the cosmonauts, while the KP and EOG indices characterize the influence of an unusual environment on their body and a gradual adaptation to it. The adaptation was apparent, in particular, by a decrease in the amount of errors and the time required to fulfill individual writing tests when repeated.

The results derived from the study show the effectiveness of the /9 methods and apparatus employed, and provide a basis for recommending their use in subsequent space flights.

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